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November 1961

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FARM LUMBER CONSUMPTION AND USE DATA:

Needs and Methods of Estimating

LAKE STATES FOREST EXPERIMENT STATION
M. B. Dickerman, Director
FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE

Foreword

The research reported here was done cooperatively by the University of Minnesota Agricultural Experiment Station and the Lake States Forest Experiment Station. The Lake States Station is maintained on the St. Paul Campus by the Forest Service, U. S. Department of Agriculture, in cooperation with the University.

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The Minnesota Agricultural Experiment Station has designated this report as Scientific Journal Series Paper No. 4521.

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FARM LUMBER CONSUMPTION AND USE DATA: NEEDS AND METHODS OF ESTIMATING

by

Allen L. Lundgren

and

Ronald I. Beazley

Introduction

Before forest managers can intelligently plan for future production on their forest lands, and before realistic forest policies for a state, region, or the nation can be formulated, predictions of future forest products demand must be made. In general, the better the understanding of the structure underlying the consumption of various forest products by different classes of users, the greater are the chances of making successful predictions of future demand. Knowledge about the consumption of forest products also is necessary if they are to be marketed efficiently. Here too, a better knowledge of forest product consumption greatly increases the probability of making successful decisions.

Of all the products obtained from forest land, timber has had, and probably will continue to have for some time to come, the largest influence on decisions and policies related to the management of commercial forest lands. Over the years one product, lumber, has dominated the market for timber both in quantity and in value. Therefore, estimates of present and future demand for lumber are of major importance in establishing forest production goals and in analyzing patterns of production, marketing, and consumption.

One of the major uses of lumber in the United States is for construction on farms. In 1952 an estimated 6.6 billion board feet was used for this purpose.[1] This amounts to 21 percent of all lumber used for construction and 16 percent of all lumber used in the United States.

What is known about this important sector of the lumber market? Although a few studies relating to lumber consumption and use on farms have been made, most of these have serious weaknesses either in the methods used or in the results obtained. Some were concerned with a restricted part of lumber use or were conceived for only a limited geographical area. Others are 15 or more years old. Agriculture has been undergoing some radical changes in recent years, yet the impact of these changes on the lumber market can only be guessed at.

In studying consumption two types of analyses generally are used: 1) cross-section analyses, which are studies of the consumption of commodities by individual consumers at one point in time, and 2) time series analyses, which are studies of the consumption of commodities by groups of consumers through time. These two types of analyses are not mutually exclusive, and both can be used together to study consumption more effectively than could be done through the use of only one method alone. However, because of the scarcity of data about lumber consumption on farms and the weaknesses in the limited amount of data available, time series analysis cannot be used at the present time.

To provide data useful both in establishing long-run aggregate demand for lumber on farms and in predicting short-run demand, a cross-section study of farm lumber consumption is needed. This would provide estimates of total and mean consumption of different kinds of lumber for different purposes and for different types of farms during a particular year or other acceptable period of time. Such a study, properly designed, also would point out existing relationships between farm characteristics and lumber use which would be useful in predicting changing patterns of lumber use over time. Local, state, and regional estimates of lumber consumption could be obtained at little extra cost. The importance of collecting information on a local basis has been emphasized by Raup in a recent paper *(8)*.

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[1] *Based in part upon pp. 374-422 in: U.S. Forest Service.* Timber Resources for America's Future. *Forest Resource Rpt. No. 14, 713 pp., illus. Washington, D. C. 1958.*

A cross-section survey would provide not only data for analyzing the present structure of the lumber market but also an excellent start towards accumulating the series of data about farm lumber consumption that is needed for making time series analyses. Before a comprehensive cross-section survey can be undertaken on an extensive scale, however, methods of obtaining data and making estimates of lumber consumption and use on farms must be worked out and tested on a smaller scale.

In 1955 a cooperative project between the Lake States Forest Experiment Station of the U. S. Forest Service and the University of Minnesota Agricultural Experiment Station and School of Forestry was undertaken to answer the question, "How can and should lumber consumption and use on farms be estimated?" This involved satisfying the following objectives:

1. To determine an effective method of identifying the kind of lumber used on farms according to use.
2. To develop an unbiased and precise method of measuring quantities of the kinds of lumber used for various purposes on farms.
3. To develop methods of classifying annual lumber consumption by types of uses according to the kind and quantity of lumber involved.
4. To develop an efficient method of sampling for lumber consumption and use on farms.
5. To survey and analyze the farm lumber consumption and use patterns in one or more areas of Minnesota.
6. To determine the major factors influencing consumption of lumber on farms at a given point in time, and to develop methods of relating these factors to lumber consumption.
7. To recommend methods for collecting farm lumber consumption and use data on a statewide basis and to indicate the cost involved in conducting such studies.

This paper presents the results of this study that relate to the development of methods for identifying, measuring, classifying, and sampling lumber consumption and use on farms, together with estimates of survey costs, and suggested improvements in these methods for use on future surveys. The data from the survey of a Minnesota economic area will be reported elsewhere.

Identifying and Measuring Lumber Use and Obtaining Related Information On Farms

The problem of estimating lumber consumption for various purposes on farms can be approached either through those who supply lumber to farmers—the lumber dealers and manufacturers—or through those who consume the lumber—the farmers themselves. Preliminary field investigations indicated that neither lumber retailers nor local sawmills could provide sufficiently precise information to determine farm lumber consumption patterns and estimate lumber consumption. This conclusion agrees with the findings of Douglas *(1)*, who questioned the validity of Iowa farm dwelling construction estimates obtained from retail lumber establishments.

To find out if the quantity of lumber used on farms over a period of time could be estimated accurately on individual farms, preliminary questionnaires and estimating forms were developed and tested on a sample of farms. This check, although it resulted in a modification of the forms tested, demonstrated that lumber consumption and use on farms could be estimated in this manner. Most farm operators could remember accurately how they had used lumber during the previous year, both for repair and new construction, although none could recall with any degree of precision the exact amounts and kinds of lumber used. An interviewer, however, could measure the different kinds of lumber used for various purposes on farms if these uses were pointed out to him by the respondent. Thus all lumber use on a given farm during the preceding calendar year could be established with a high degree of accuracy. Attempts to gather data for a longer period of time were not successful because most respondents were unable to recall accurately where or how they used lumber more than a year prior to the survey.

Thus, the approach adopted in this survey was to have interviewers contact individual farms and, using the estimating forms and questionnaires developed, measure and record the kind and amount of lumber used for various purposes on the farm during the previous calendar year.

DEFINITIONS AND BASIC PRINCIPLES

In this study lumber was defined as being any solid, sawn wood product commonly sold by lineal—or board-foot measure. Only new lumber, that is, lumber that had not been used before, was considered in detail. The respondent was asked, however, to estimate the quantity of old lumber used on the farm during the previous year, both for repair and for new construction.

Repair was defined as the replacement in an existing structure of a part having the same functional use as before. New construction was defined as the addition of a new structure, or a new part of an existing structure having a new functional use. Repair and new construction were estimated only for structures where the work had been completed (but not necessarily begun) during the calendar year being considered, or where enough work had been done to allow the structure to be used during this period. This was done for consistency and to simplify the field estimating procedures. It is unlikely that this procedure caused much bias in estimating lumber use, since most of the construction was completed within the same calendar year it was begun. These definitions and concepts worked satisfactorily in the field and, in fact, seemed to appeal to farm operators.

The basic principle guiding all lumber estimating in this study was that enough information on construction details should be taken so that accurate estimates could be made in the office of the quantities of lumber used in construction, fully qualified as to origin, species, surface, grade, and functional use. The lumber estimating forms were designed to aid the interviewer in making estimates of lumber use; they were not intended to be a complete substitute for judgment on the part of the interviewer.

Obtaining all of this information about lumber use meant that the interviewer actually had to see the construction so that he could identify, describe, and measure the lumber involved. In almost every case this proved to be relatively simple. The person being interviewed was asked to recall instances of construction and to show these to the interviewer. Common instances of construction were suggested to the respondent to help jog his memory. The interview was not terminated until the interviewer was satisfied that all instances of lumber use on the farm during the previous year had been obtained.

Although the interviewing procedure used may sound rather complex when described, it was relatively easy to carry out in the field. Almost all of the respondents were willing to cooperate in providing the desired information, and interviewers encountered little difficulty in making estimates of lumber use on farms.

ESTIMATING LUMBER USED FOR REPAIR

Most repair jobs on farms involve relatively small quantities of lumber. Once the repair job had been pointed out to the interviewer, the amounts and kinds of lumber involved usually could be readily determined. A rather simple form was adequate for tallying the quantities involved in most instances.[2]

How much information to gather posed a major problem. The more information desired about kinds of lumber and use, the more complex must be the estimating form. After considering many possibilities, it was decided to gather the following information about the kind and use of lumber for repair:

1. Type and use of structure repaired (for example, cattle barn, fence gate, wagon).
2. Part of structure repaired (for example, roof, wall, floor).
3. Origin of lumber (whether grown on own farm or obtained from a local mill or dealer).
4. Functional use of lumber (sheathing—1 inch or less in thickness, or framing—more than 1 inch in thickness).
5. Surface of lumber (whether dressed or rough).
6. Lumber species (name if known, or softwood or hardwood).
7. Grade of lumber (grade if known, or mill run).
8. Quantity of lumber used for each combination of the above qualifications.

In addition to the above information, the cause of repair, age of the building repaired, month of the year repaired, the quantity of treated lumber used, and the price of lumber or the cost to saw it if not purchased, also were obtained.

Before the final estimating forms were adopted, several preliminary versions were developed, subjected to field trials, and subsequently revised. One of the more troublesome problems was that of providing enough space to include all of the detail required in order to specify as completely as possible the kind of lumber and its use. An additional complication was that the information had to be recorded so that it could be aggregated by kind or use of lumber in any way desired. This meant that each time any one of the qualifying factors listed above changed, a new set of information as to the quantity used had to be obtained.

As an example, assume that the *wall* of a barn had been repaired using lumber, some of which was Douglas-fir, graded, surfaced, less than 1 inch thick, and obtained from a dealer, and some of which had the same qualifications except that it was more than 1 inch thick. The quantity less than 1 inch thick and the quantity more than 1 inch thick would be estimated separately. If, in addition, the same kind of lumber had been used to repair the barn *floor,* this quantity would be estimated separately from the others. Spaces for making these separate estimates were provided on the repair and the repair-continuation form. These same general principles also applied to the estimation of lumber used for new construction.

ESTIMATING LUMBER USED FOR NEW CONSTRUCTION

Estimating the amount and kinds of lumber used for new construction on farms required a more complex set of questionnaire forms than those used for estimating repair. The new-construction forms underwent an extensive period of field testing and revision before the final set used in the survey was developed. The first set of two forms, when pre-tested in the field, were found to be greatly oversimplified. Although they did provide space for recording the information desired by the survey, they did not help the interviewer in performing his most difficult task, that of actually measuring and estimating the quantities of lumber used in a particular instance of new construction.

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[2] *A complete set of forms used for estimating consumption of lumber for repair and new construction and for recording other farm information, together with detailed instructions to interviewers, are included in the project outline for this study, copies of which are on file at the School of Forestry and at the Lake States Forest Experiment Station, both located on the St. Paul Campus of the University of Minnesota, St. Paul, Minnesota.*

A book by E. A. Malm, *Estimating Charts for Farm Buildings (7),* helped to solve this problem. Using the diagrams and lists of materials in this book as source material, with the author's permission, a set of forms were developed that proved extremely useful in the field. They provided the interviewer with a structural diagram of each major type of building, a form for computing the quantities of the different kinds of lumber used for various purposes in the building, a sheet for diagraming portions of the building as an estimating aid, and a check list to insure that all the details of new construction had been obtained.

In filling out these forms, the interviewer recorded the basic dimensions of the various pieces of lumber in the building, together with the qualifications of the lumber (species, surface, etc.). The same qualifications that were obtained for repair were also obtained for new construction. Diagrams of each newly constructed building were made, using a check list as a guide. These diagrams, showing the dimensions of the various parts of the building, were used later in the office to compute the actual quantities of lumber involved.

Diagraming structural parts of farm service buildings was not difficult because most of these buildings are unfinished on the inside and the structure of the building is visible. For farm houses, however, more difficulties in estimating were expected. Arrangements had been made with a local architect to obtain detailed specifications of typical houses in this area which would have provided a close approximation of the quantities of lumber used in most farm house construction that might be encountered. As it turned out, no new farm houses occurred in the sample so it was unnecessary to use this information.

OBTAINING RELATED FARM INFORMATION

One of the objectives of this study was "to determine the major factors influencing consumption of lumber on farms at a given point in time, and to develop methods of relating these factors to lumber consumption." If lumber consumption and use on farms could be related to certain farm characteristics such as farm size, income class, type of farm, tenure of operator, and number and volume of buildings, then these relationships could be used to estimate lumber consumption and use on other farms.

To satisfy this objective, information on the farm characteristics specified above was collected. Definitions of the various items of general farm information included in this questionnaire followed closely those used in the 1954 Census of Agriculture. A special form provided space for recording enough information to compute the floor area and the cubic volume of each building on the farm.

Sampling Design

Once it had been decided to use individual farms as the source for lumber consumption and use information, and after a means of getting this information had been developed and field tested, a method for selecting sample farms to be interviewed was devised. For the purposes of this survey, a farm was defined as a place having a normal annual income of at least $250 from the sale and/or exchange of farm products. This followed the 1954 Census of Agriculture definition of commercial and part-time farms; farms classed as residential by the Census were not included.

The Bureau of the Census has divided Minnesota into eight nonmetropolitan and two metropolitan economic areas (figure 1). In effect, the population of farms within the State has been stratified into several relatively homogeneous subpopulations of farms. To confine the survey to a relatively homogeneous farming area, thus likely reducing the variance of the lumber consumption and use estimates, one state economic area, No. 4, was selected as the survey area.

Minnesota Economic Area No. 4 consists of eight counties: Morrison, Benton, Sherburne, Mille Lacs, Kanabec, Isanti, Chisago, and Pine. In 1954 it contained an estimated 13,911 farms, according to the Census; 11,783 were classed as commercial farms. By the time of this survey in 1955, it was estimated that the total number of farms had decreased to 13,432. This assumes that the area experienced the same decline in numbers of farms from 1954 to 1955 as it did annually from 1950 to 1954.

At the time this survey was being planned, preliminary results from the 1954 Census of Agriculture *(12)* were just being published. To facilitate checking survey results such as numbers of farms by size class, income class, and type of farm with the Census results, thus providing an exogenous measure of the sample reliability, the survey field work was done during the summer of 1955, and data on lumber consumption and use were gathered for the calendar year 1954.

ALTERNATIVE SAMPLING METHODS

In designing this survey several different sampling methods were considered: 1) sampling individual farms from a list, 2) point sampling of individual farms from a map, 3) area sampling by point selection, 4) sampling of minor civil divisions or smaller land divisions such as sections, and 5) sampling variable sized areas, each containing approximately equal numbers of farms with a controlled range of numbers.

Sampling of individual farms tends to be inefficient because the sample is likely to be scattered over the entire area, requiring a large amount of travel time. Additional drawbacks often encountered in sampling from a list are: the list may not be up-to-date, the definition of a farm for survey purposes may not agree with the definition of a farm used in drawing up the list, and interviewers may find it difficult and costly to locate the sample farm on the ground. Point sampling of individual farms on a map has a built-in bias; large farms or farms in areas where there are few farms have a greater probability of being included in the sample than do small farms or farms in a more densely populated neighborhood *(2, pp. 66-68)*.

An alternative to sampling individual farms is area cluster sampling, where areas that may contain several farms are selected as the basic sample unit. A major difficulty with point selection of areas is that the boundaries of the areas chosen would be difficult and costly to locate in the field. In addition, the number of farms per sample unit would vary widely, resulting in increased variance of estimated totals *(2, pp. 336-340)*. This would also make it difficult to predetermine the sampling rate or estimate the survey cost. Similar objections can be raised against the use of land divisions such as sections or minor civil divisions for sample units. In addition, the use of large-size area clusters such as minor civil divisions can

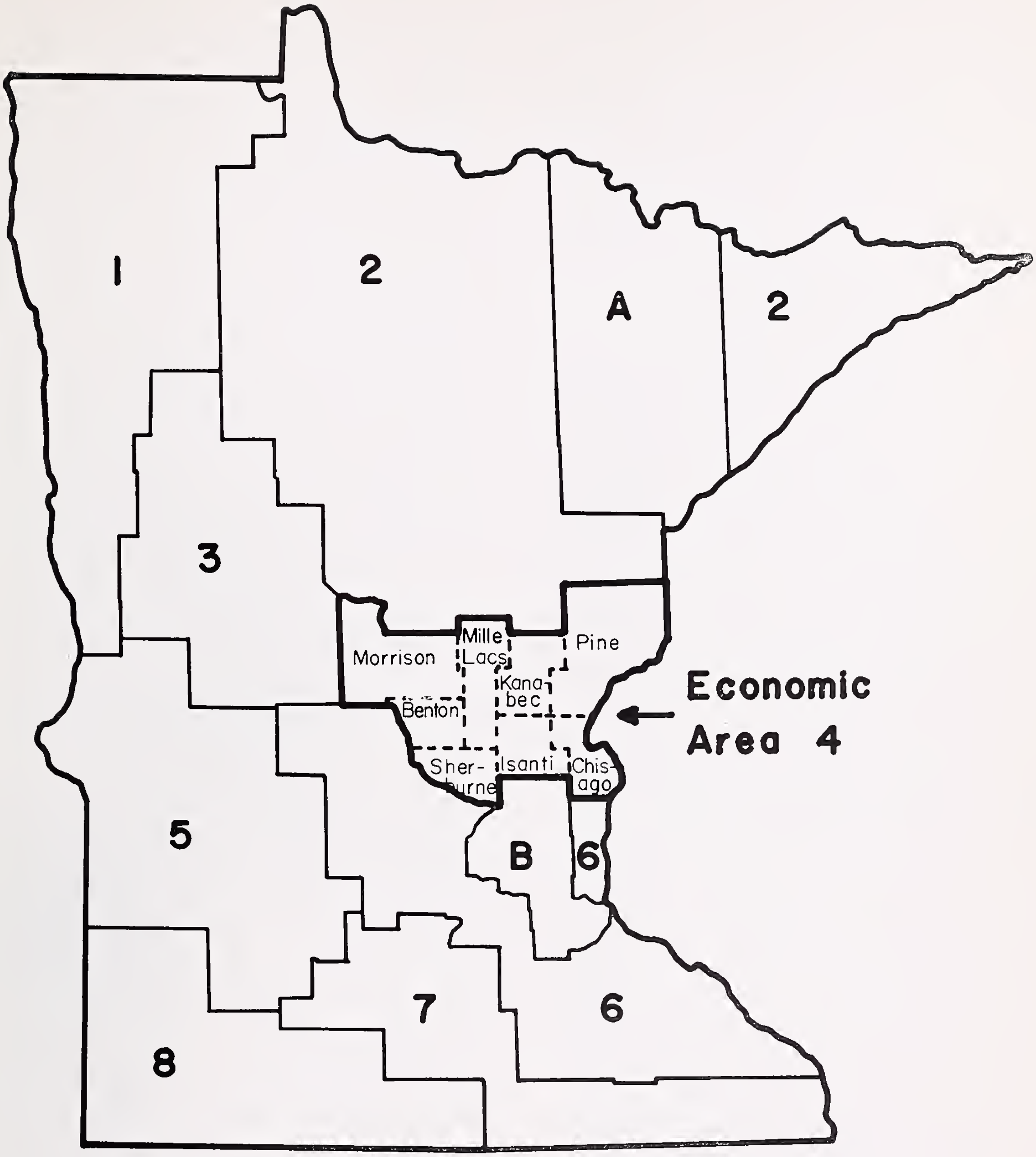


Figure 1.—Minnesota economic areas, 1954 Census of Agriculture.

result in poor geographical coverage when sampling at low intensities.

Sampling from a list of areas of variable size, each with the same number of farms and each with boundaries easily identifiable on the ground, insures that all farms have an equal chance of being included in the sample, that the variance of estimates resulting from unequal numbers of farms in the sample is known and controlled, and that interviewers can locate the sample areas accurately on the ground with a minimum of effort. If the areal listing is made on a geographical basis, a distribution of sample units over the entire area can be insured by the use of an appropriate sampling technique.

A system of sampling farms in this manner already has been drawn up to cover the entire United States, county by county. This system, the Master Sample of Agriculture, is an areal delineation that was designed in 1943 by the U. S. Bureau of Agricultural Economics in cooperation with the U. S. Bureau of the Census to provide a national sample of farms *(6)*. Some of the sampling work maps were revised in 1947, but up to the time of this survey no other revision of the sample had been made. Even though the data were somewhat out of date, it appeared to offer the best method for obtaining a sample of farms for this survey, so it was adopted.

Three areal divisions are recognized in the Master Sample: 1) incorporated areas, 2) unincorporated areas relatively densely populated, and 3) unincorporated areas relatively sparsely populated *(5)*. These often are referred to as urban places, rural places, and open country areas, respectively. Urban places include all incorporated places with a population of 2,500 or more in 1940. Rural places include all name places, excluding incorporated areas, having a population of 100 or more, and rural areas having a population density of at least 100 persons per square mile as of 1940. The rest is called open country area.

In 1940, urban places contained only 1 percent of the total number of farms in the United States *(4)*. Because the four urban places in Minnesota Economic Area 4 were expected to contain only a small fraction of the farms in the survey area, they were eliminated from the sample. The remaining two areal divisions, rural places (which contained an estimated 8 percent of all farms in the U. S. in 1940) and open country areas (which contained about 91 percent), were included in this survey. Since the sampling method used in open country areas differed considerably from that used in rural places, each is discussed separately.

OPEN COUNTRY AREA SAMPLING

The Master Sample of Agriculture provides two basic sets of materials for use in drawing open country area samples and locating sample unit areas on the ground. The first of these is a set of enlarged (scale: 1 inch = 1 mile) county highway maps on which farm locations are shown. On these maps, minor civil divisions (townships) within each county are outlined and numbered contiguously in a serpentine manner beginning at the northeast corner of the county and proceeding west in a manner similar to the ordering of sections within a township. Each minor civil division (m.c.d.) is divided into small areas, called count units, the boundaries of which are identifiable on the ground. Within each m.c.d., the count units are numbered contiguously in a serpentine manner beginning at the northeast corner of the m.c.d. and proceeding toward the west. Each of these count units contains from one to seven or more elementary sample units which are not delineated on the county map. The *number* of sample units within each count unit is shown on the map, however.

The second set of materials provided is a tabulation of sampling information for each county. This lists minor civil divisions in numerical order, and for each m.c.d. it lists the count units in order. For each count unit the tabulation provides the following information: 1) the number of farms indicated on the map within the count unit boundaries, 2) the indicated number of dwellings, 3) the number of sample units assigned to the count unit, and 4) the cumulative number of sample units from the start of the county listing. From this list, sample units can be selected for a survey by various sampling procedures.

The number of sample units assigned to an individual count unit depends upon the number of farms shown on the map within the boundary of the count unit. When the Master Sample first was designed, the number of sample units assigned to each count unit in the area covered by this survey was controlled so that each sample unit would contain 4 ± 2 farms, as indicated on the map. Because of a decrease in the number of farms since the sample was designed, the expected number of farms per sample unit in economic area 4 at the time this survey was made had dropped to about 3. However, even though it had been many years since the Master Sample of Agriculture sample units were first set up, they still provided close control over the number of farms per sample unit in this survey (fig. 2).

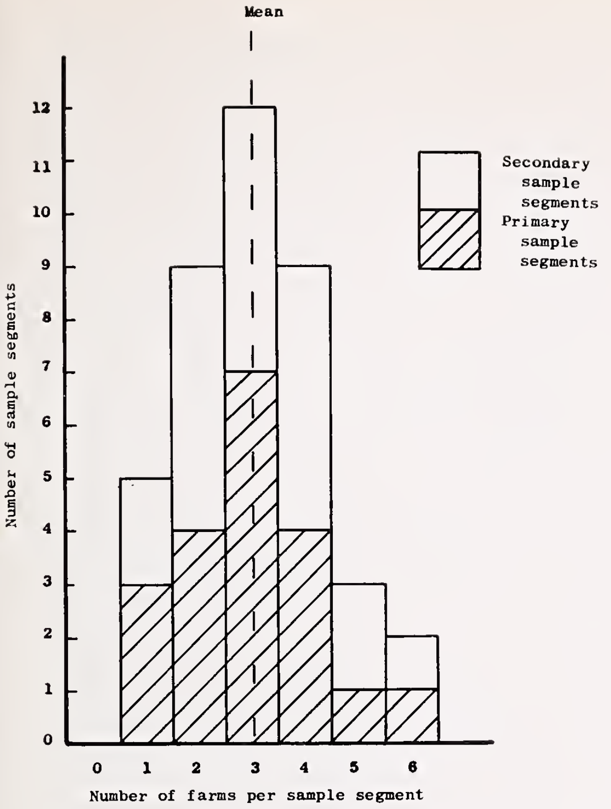


Figure 2.—Number of farms per sample segment, primary and secondary open country sample, Minnesota farm lumber consumption survey, economic area 4, 1954.

If no one-to-one correspondence exists between farms indicated on the map and farms actually found on the ground, control over the number of farms per sample unit may not be as good as expected. Although this discrepancy may not be very large, it undoubtedly exists. However, the Master Sample provides better control over the number of farms per sample cluster than other area sampling methods.

It is not necessary to use a farm cluster of only one elementary sample unit as the basic sample unit in a survey. The elementary sample units can be combined so that a survey sample unit would consist of two, three, or even more units if desired. However, as the number of farms per cluster increases, the number of clusters that can be included in a survey of given intensity decreases. When the sampling rate is low, large cluster sizes may result in poor geographical coverage of the area.

Compared to simple unrestricted sampling of individual farms, cluster sampling of the type used in the Master Sample results in a larger sampling error of estimate when farms within clusters are intercorrelated such that the correlation coefficient is greater than $-\frac{1}{NM-1}$, where N is the number of clusters in the population, and M is the number of individual sampling units (farms) per cluster *(11, p. 245)*. When the intra-cluster correlation coefficient is greater than $-\frac{1}{NM-1}$, then the more farms included in the cluster, the larger will be the expected error of estimate between clusters, with a given sample size. Therefore, the reduced cost associated with interviewing farms that are located together must be weighed against the expected increase in the error of estimate. If the intra-cluster correlation coefficient is very small it may be possible to ignore the effect of cluster size on the error of estimate; but if it is large this effect should be considered in designing the survey.

In this survey the intra-cluster correlation coefficients of lumber used for new construction and for all purposes were both small. Cluster sampling for these estimates was about as efficient with respect to sampling error as individual farm sampling would have been. Cluster sampling for making repair estimates, however, was less than half as efficient as sampling individual farms; the intra-cluster correlation coefficient was positive and large. Apparently, adjoining farms tend to use similar amounts of lumber for repair. These considerations should be kept in mind when designing future surveys of lumber consumption on farms.

A random selection of areal sample units from a list does not necessarily result in good coverage of the area sampled. Sample units chosen in this way can cluster in certain parts of the survey area. For this reason, a single random-start, systematic selection of sample units that would insure a reasonable distribution of sample units throughout the area offered a good approach to this sampling problem.

In systematic sampling, if there is a periodicity in the population being sampled, and if the sampling interval coincides with the periodicity of the population, the variance of the sample estimate will be biased *(2, p. 504)*.

To reduce the chance of periodicity in the listing order of the present survey, the eight counties were ordered in a north-south serpentine manner beginning with Morrison County in the northwest part of the area. Next, all of the minor civil divisions within the seven counties following Morrison were renumbered so that the m.c.d.'s within the economic area were ordered contiguously from start to finish. This reduced the likelihood of selecting two sample units located close to one another and likely minimized periodicity. A schematic illustration of the ordering of m.c.d.'s within economic area 4 is given in figure 3. An example of the ordering of m.c.d.'s within a county, and of count units within an m.c.d., is given in figure 4. The missing m.c.d. numbers were numbers assigned to rural places.

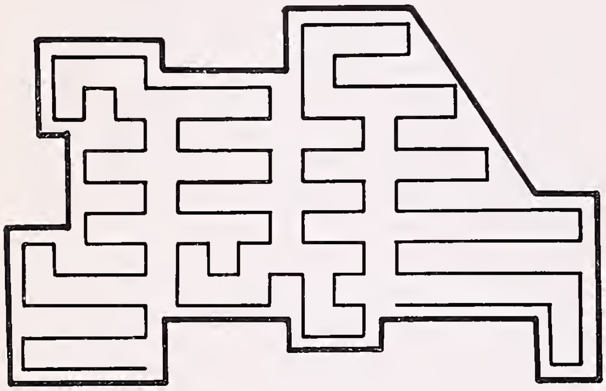


Figure 3.—A schematic diagram of the ordering of minor civil divisions in Minnesota economic area 4 for the farm lumber consumption survey.

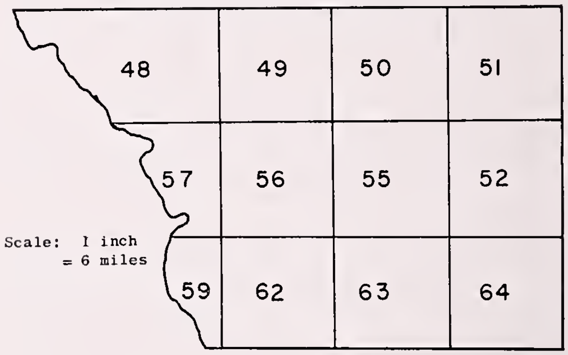
A tabulation of all the m.c.d.'s and count units in survey area, similar to the one provided with the Master Sample of Agriculture materials, was made using the renumbered m.c.d.'s. This tabulation contained 3,937 elementary sample units.

Preliminary field checks indicated that new construction would be encountered on about 10 percent of the farms, and repair on about 20 to 30 percent of the farms. Because of this, and the expectation that new construction estimates would have a greater variance than would repair estimates, new construction lumber use was sampled at twice the rate used for sampling repair.

From the list of 3,937 sample units, 20 were selected systematically, using a single random start. These were designated as primary sample segments and comprised the primary sample. For every farm on these units interviewers completed a questionnaire about general farm information and lumber use for all purposes. In addition to the primary sample, 20 sample units, each contiguous to a primary sample unit, were designated as secondary sample segments and comprised the secondary sample. On the secondary sample segments the interviewers contacted all farms but completed a questionnaire only for those farms that reported using lumber for new construction. Repair and all lumber use thus were sampled at a rate of 0.5 percent, and new construction at a rate of 1.0 percent. A primary and its companion secondary sample segment made up a total sample segment.

The primary, secondary, and total sample segments were outlined on standard county highway maps as an aid to the interviewers in locating the sample segments in the field. An enlarged map of each total sample segment was made, showing the farms indicated on the county maps (see fig. 5 for an example). The indicated farms were used by the interviewer only as a guide in locating all farms within the sample area.

Ordering of minor civil divisions



Ordering of count units in minor civil division 51.

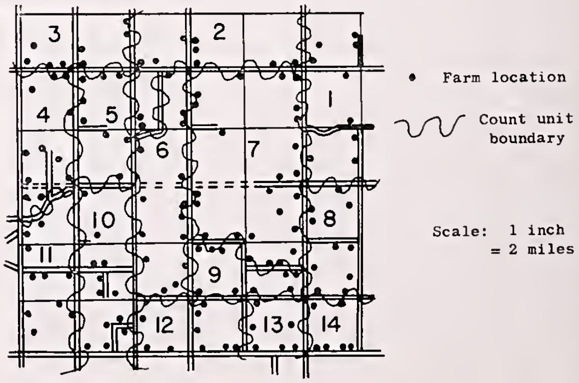


Figure 4.—Ordering of minor civil divisions, and of count units in minor civil division 51, Benton County, Minnesota farm lumber consumption survey.

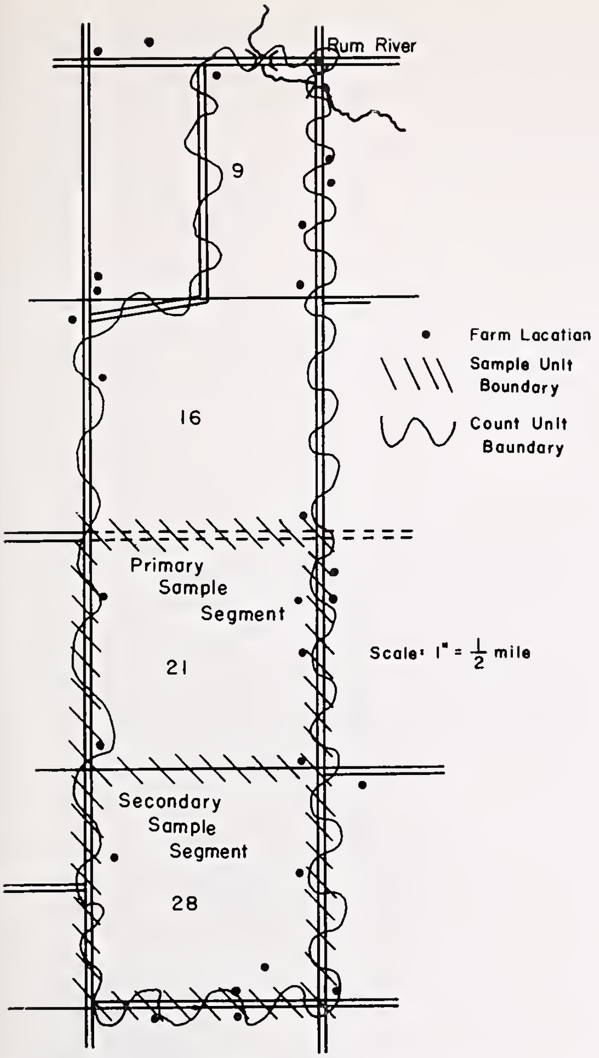


Figure 5.—Sample segment 5, count unit 6, minor civil division 51, Benton County, Minnesota farm lumber consumption survey.

All places of residence within the primary sample segment were visited to determine if they were farms according to the survey definition (a place having a normal annual income of at least $250 from the sale and/or exchange of farm products). For each farm a general farm information and lumber use questionnaire was completed. If no one could be found at a place of residence after three calls, a decision was made from the best evidence available as to whether or not it should be classified as a farm.

Next, all places of residence in the secondary sample segment were contacted, but a questionnaire was filled out only for those farms that had used lumber for new construction during the previous year. For each farm in the primary sample segment where no one could be found at home, one of the farms in the secondary sample segment was selected at random and designated as a substitute. If this substitute farm also was a nonrespondent, another farm was similarly chosen. All substitute farms were completely enumerated. For nonrespondent farms in the secondary sample segment apparently having new construction, an average of lumber consumption on all farms with new construction in the total sample segment was assigned in the office. If no other farms in the sample segment had new construction, an average of lumber consumption and use on all farms with new construction encountered in the entire sample was used.

The 20 sample segments included in the primary sample had an expected number of 3 farms each, so 60 farms were expected in the primary sample. An additional 60 farms were expected in the secondary sample, making a total of 120 farms expected in the total sample. In the survey 122 farms were actually found. If 10 percent of these farms had new construction, as was expected, 12 occurrences of new construction should have been encountered in the survey. As it turned out, new construction was found on 30 farms. From 12 to 18 farms were expected to have used lumber for repair; in the survey, 16 farms reported such use.

RURAL PLACE SAMPLING

Rural places accounted for only 4 percent of the number of farms in Economic Area 4. Because they occupy a minor place in the area's farm lumber consumption picture and since it is not recommended that rural places be sampled in future surveys, in view of the additional cost per interview, only a brief outline of the rural place sampling procedure used in this survey will be given here.

Sampling rural places presented special problems, since the list of rural places included in the Master Sample of Agriculture gave no indication of the number of farms in each rural place, and county highway maps did not show farms within rural places. When preliminary checks showed that rural places varied considerably in size and in numbers of farms, it was decided to construct sample units containing approximately equal numbers of farms.

Once these sample units had been constructed, they were ordered in a serpentine manner, and 5 percent of the 141 sample units in the area were selected systematically, using a single random start. The selected sample units were called total sample segments. Within each total sample segment two farms were chosen at random and designated as the primary sample segment. The secondary sample segment was made up of all the remaining farms in the total sample segment that reported new construction, The interviewing procedure was identical to that used in the open country area.

Method of Analysis

The survey described in the preceding sections was designed to furnish two general types of information about the consumption and use of lumber on farms in Minnesota Economic Area 4: 1) estimates (and their standard errors) of population parameters such as total numbers of farms and quantities of different kinds of lumber used for different purposes, and 2) relationships between specified farm characteristics and lumber consumption and use. Each of these two types of information requires a different method of analysis, so each is discussed separately.

ESTIMATING POPULATION PARAMETERS

Both open country and rural place samples were selected systematically, using a single random start. This sampling method does not permit the calculation of an unbiased estimate of variance, but this difficulty usually can be overcome by regarding each sample unit included in the sample as having been randomly selected from a stratum the size of the sampling interval, and pairing adjacent sample segments *(3, pp. 237-238)*. Thus, strata of a size equal to twice the systematic sampling interval are constructed in the population, and each successive pair of sample segments is assumed to have been randomly selected from a stratum.

Two general types of estimates of population parameters were sought in this survey: totals, such as numbers of farms and quantities of lumber used by farms, and means, such as average size of farms and amount of lumber used per farm. Because the method of sampling farms in the open country area was not the same as that used in rural places, different formulas were used to obtain some of the estimates. The formulas for estimating open country totals and means are outlined briefly below. A more detailed explanation of these formulas and a discussion of the formulas used for making rural place and total economic area estimates are given elsewhere.[3]

Total numbers of farms and quantities of lumber used in the open country area were estimated by the following formula:

$$\hat{Y} = \sum_{i=1}^{g} M_i \frac{1}{m_i} \sum_{j=1}^{m_i} y_{ij}$$

where:

g = Number of strata.

M_i = Total number of single or double sample units (depending upon what is being estimated) in the i^{th} stratum.

m_i = Number of sample segments (either primary or total sample segments, whichever pertains) included in the sample in the i^{th} stratum.

y_{ij} = The number of farms or the quantity of lumber in the j^{th} primary or total sample segment of the i^{th} stratum, as obtained from the survey.

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[3] *Unpublished Ph.D. thesis by Allen L. Lundgren. Farm lumber consumption and use: methods of estimating and results of an east-central Minnesota survey. University of Minnesota. 260 pp., illus. 1959. A copy also is on file at the Lake States Forest Experiment Station, U. S. Forest Service, St. Paul 1, Minn.*

The general formula used to calculate the variance of the above estimate is:

$$s_{\hat{Y}}^2 = \sum_{i=1}^{g} M_i^2 \frac{1}{m_i(m_i-1)} \sum_{j=1}^{m_i} (y_{ij} - \bar{y}_{si})^2$$

where:

$\bar{y}_{si}$ = Mean number of farms or mean total lumber use per sample segment in the i^{th} stratum.

$$= \frac{\sum_{j=1}^{m_i} y_{ij}}{m_i}$$

The above formula for the variance is greatly simplified if only two sample segments are included in each stratum, as was done in this survey. If $m_i = 2$, the formula reduces to:

$$s_{\hat{Y}}^2 = \sum_{i=1}^{g} \frac{M_i^2}{4} (y_{i1} - y_{i2})^2$$

where $(y_{i1} - y_{i2})$ is the difference between the observations of the two sample segments included in the i^{th} stratum.

For estimating mean lumber use on farms in the open country area the following formula was used:

$$\hat{\bar{y}} = \sum_{i=1}^{g} \frac{M_i}{M} \frac{1}{m_i} \sum_{j=1}^{m_i} \frac{1}{n_{ij}} \sum_{k=1}^{n_{ij}} y_{ijk}$$

where:

M = Total number of sample units in all of the strata being considered.

n_{ij} = Number of farms in the j^{th} segment of the i^{th} stratum.

y_{ijk} = Quantity of lumber used on the k^{th} farm in the j^{th} segment of the i^{th} stratum.

The variance of the estimated mean was calculated by the following formula:

$$s_{\hat{\bar{y}}}^2 = \sum_{i=1}^{g} \left(\frac{M_i}{M}\right)^2 \frac{1}{m_i(m_i-1)} \sum_{j=1}^{m_i} (\bar{y}_{ij} - \bar{y}_i)^2$$

where:

$\bar{y}_{ij}$ = Mean quantity of lumber used per farm in the j^{th} segment of the i^{th} stratum.

$$= \frac{\sum_{k=1}^{n_{ij}} y_{ijk}}{n_{ij}}$$

$\bar{y}_i$ = Mean quantity of lumber used per farm in the i^{th} stratum.

$$= \frac{\sum_{j=1}^{m_i} y_{ij}}{m_i}$$

When estimating some means, one or more sample segments were devoid of observations. For example, in estimating mean lumber use for repair on different size classes of farms, several segments did not contain farms in certain size classes. Where this occurred, the "empty" segments were set aside and new strata were formed by pairing the remaining segments.

ESTABLISHING RELATIONSHIPS AMONG THE DATA

In establishing relationships between some variables such as the volume and the number of buildings on a farm, standard regression techniques were used. In the analysis, clusters often were ignored and individual farms were treated as though they had been selected at random from the population. This assumption should not greatly affect the results since the intracluster correlation was small.

For some relationships, such as that between the total volume and the floor area of buildings on a farm, where the standard deviation of the dependent variable increased with the size of the independent variable, ratio estimation was better suited to the data than was standard regression analysis. Here too, data on individual farms were used.

Because Census of Agriculture definitions were used for much of the general farm information in this survey, and because much of this information was taken for the same year covered by the census, it was possible to check survey results with the census, using the chi-square analysis to compare frequency distributions. Standard procedures as given by Snedecor *(10)* were followed in establishing and testing these and other relationships.

A major problem in analyzing the data collected on the survey was the testing of hypotheses concerning relationships between lumber use and specified farm characteristics. Unfortunately, the use of regression analysis for this purpose could not be justified because of the heterogeneous variances involved. Other methods, such as analysis of variance and F and t tests designed for use with heterogeneous variances, could be used, however. Generally, appropriate procedures given by Snedecor *(10)* were followed in making these analyses. Although tests of this nature are not as useful in establishing relationships as regression analysis, they do indicate the probability that apparent differences between mean lumber use by different types of farms are real differences.

The testing of hypotheses raises a question as to what level of significance should be adopted in making these tests. In surveys of this nature, and especially when sampling for characteristics which have a large variation both in occurrence and in magnitude, such as lumber use on farms, low levels of significance usually are satisfactory. Generally, the 30-percent level of significance was used for testing statistical hypotheses in this survey, although in most instances the actual level of significance at which a statistical hypothesis was rejected (or accepted) was given, rather than just stating that a particular hypothesis was accepted (or rejected) at a specified minimal level of significance.

Recommendations for Future Surveys

The immediate need in studying lumber consumption on farms is to test the methods and techniques developed in the study just described on a larger scale. Before undertaking an expanded survey, however, some modifications of the techniques and methods developed by the present project should be considered. Among those which will be discussed are changes in the information collected on the survey, changes in the sampling design and in the intensity of sampling, and some modifications of estimating techniques for large-scale repeated surveys. Since many of the suggested changes are based upon the cost information collected on the present survey, this is presented below.

SURVEY COSTS

As part of the survey of Economic Area 4 a record of the field costs of each interviewer was maintained, showing the time spent and the distance traveled for each major activity such as interviewing, travel around sample segments, and travel between sample segments, together with other miscellaneous expenses. A summary of these data is given below.

Activity	*Miles*	*Man-hours*	*Cost*[1]
Field work:			
Travel outside of sample segments	5,284	156.5	$ 683
Travel within sample segments	664	75.0	196
Interviews	—	89.5	179
Miscellaneous time	—	19.0	38
Miscellaneous expenses	—	—	174
Total field work	5,948	340.0	$1,270

[1] *$.07 per mile, $2.00 per hour for field work.*

The time spent in interviewing amounted to only about one-fourth of all the time spent in the field. Almost half of the time was spent in traveling from one sample segment to another or from the base point to a sample segment. About a fifth of the time and almost a third of the mileage were used for callbacks, that is, trying to contact a farm operator to get an interview after the first try. This points out the need to keep callbacks to a minimum in this type of a study.

On the farms completely interviewed, the average interview lasted just short of an hour. No interview exceeded 135 minutes, and some took as little as 15 minutes. The mean interview time on farms that did not use lumber was 42 minutes, while on the farms using lumber it was 69 minutes. The longer time to complete an interview on farms using lumber is, of course, what would be expected, as additional forms had to be filled in.

The field cost of the 82 complete interviews was $1,270, an average of $15.50 per completed interview. More than 80 additional places were contacted to determine if they were farms, and if they were, whether they used lumber for new construction. Because these places had to be contacted anyway, the sampling intensity for repair, for all lumber use, and for data on farm characteristics could have been doubled (from 0.5% to 1.0%) with only a relatively small increase in the cost of the field work. This would have meant additional interviewing 65 farms in the open-country and rural-place secondary sample at an extra cost of about $150, an increase of slightly more than 10 percent in the total cost of the field work. The average cost per completed interview on these farms would have been about $2.30, compared to an average interview cost of $15.50 on the original survey. Had all of the farms in the primary and secondary sample been interviewed, the average cost per interview would have been about $10.00. Future surveys should consider such possibilities for enlarging the coverage of the survey at a small increase in total cost, while also reducing average cost.

CHANGES IN INFORMATION COLLECTED

The elimination of unnecessary questions from the survey schedule can result in a saving of both field and office time. One of the more tedious and time-consuming parts of the analysis was computing the volume of buildings on each farm. An analysis of the survey data indicated that the floor area of buildings on each farm was a good predictor of the volume of buildings. If lumber consumption on farms were related to building volume, floor area could be used as an estimator of volume at a considerable saving in computing time and with only a slight loss in accuracy. An even greater saving could be realized by using the number of buildings as a predictor of volume, although the relationship is not precise for a sample of the size used in this survey.

Another important change in the information collected can be suggested: more information about the consumption and use of old lumber (that is, previously used lumber) for both repair and new construction should be obtained in future surveys. Although it would not be practicable to estimate the kind (species, surface, grade, etc.) of old lumber used on a farm, inferences as to the substitution of old lumber for new could be made if the uses of old lumber on farms were specified.

If future surveys of farm lumber consumption are to be a part of a program for collecting information about all wood consumption, as they should be, data about farm use of other kinds of wood besides lumber should be collected. With only a small increase in cost and complexity of the schedule, data on the use of fence posts, poles, plywood, shingles, and other wood products on farms could be obtained. Thus, in one survey the entire wood consumption picture on farms would be available.

Although many changes in the lumber estimating forms used in this survey could be suggested, most of them would be relatively minor. Furthermore, the design of a schedule will depend upon the information desired. The schedule developed for this survey worked very well in the field and should furnish an excellent model for future surveys in this area. In other areas, the schedule would have to be modified to allow for different kinds of buildings. If information about other wood consumption besides lumber is to be obtained, some additional changes would also have to be made.

CHANGES IN SAMPLING DESIGN

In planning future surveys, several modifications of the sampling design used in this pilot survey should be considered. Preliminary field trials had indicated that repairs would be encountered from two to three times as often as new construction. Because of this, and because it was expected that the variances of new construction estimates would be larger relatively than those of repair, new construction was sampled at twice the rate used for repair. When the survey was made, however, the incidence of new construction was found to be about the same as the incidence of repair. At the sampling intensities used, the relative variances associated with estimates of total and mean lumber use for new construction were about half those associated with repair estimates. If new construction and repair had been sampled at the same intensity, the relative variances of the repair estimates would have been slightly less than those of the new construction estimates.

It is recommended that on future surveys all lumber use be sampled at the same rate. This would greatly simplify the analysis and increase the efficiency of the sampling design. Since new construction accounts for the major part of lumber use, a sample designed to provide specified relative variances of new construction estimates would tend to provide similar relative variances for total lumber use estimates and for repair estimates.

On future surveys rural place farms could be eliminated from the sample without much effect on the estimate of total farm lumber consumption. By excluding them, much expense in planning surveys, carrying out field work, and analyzing data would be saved—perhaps as much as a quarter of the survey cost. In most areas of the country only a small proportion of farms occur in rural places (4 percent in Minnesota Economic Area 4), so almost all of the lumber use on farms would be accounted for by a survey of open country farms alone. The survey of Minnesota Economic Area 4 indicated that farms in rural places did not differ significantly from farms in open country areas in lumber consumption or other characteristics such as size and income. If the number of farms in rural places is known, perhaps direct ratio estimates derived from the open country area survey could be applied to rural places to adjust the survey estimates. This procedure should provide satisfactory estimates of total lumber consumption on farms.

In the present survey of Economic Area 4, only commercial and part-time farms were included, but in future surveys residential farms should be included in the sample. Since all farms in a sample unit must be contacted anyway to determine if they are a farm according to the survey definition, a questionnaire could be filled out for all residential farms at little additional cost. Although the amount of lumber and wood used by these farms is probably small, including them in a survey would give a complete picture of lumber and wood use by all farms in an area.

In future surveys two sample units (as defined in the Master Sample of Agriculture) should be used as the elementary sample unit for sampling both repair and new construction. There was some correlation ($r_{ps} = 0.3458$, significant at the 10- to 20-percent level) between lumber use for new construction in the primary and in the secondary sample of this survey; this correlation would tend to reduce sampling efficiency if a cluster of two units were used as the elementary sample unit. However, considering that the analysis would be simplified and that travel costs would be reduced considerably, a net gain in sampling efficiency from using a double-sized sampling unit seems likely.

One further change in sampling design remains to be considered. Recently, a method of systematic sampling using multiple random starts has been proposed for surveys of this nature *(9)*. This sampling method resembles cluster sampling with several clusters, yet it retains most of the advantages of systematic sampling. Its main advantage over a single random-start systematic method is that exact estimates of the sampling variance can be calculated directly. Furthermore, estimates of population parameters can be obtained more simply through this method than through the method used on this survey. It is recommended that on future surveys systematic sampling with a multiple random start be considered. Using a multiple rather than a single random-start systematic sampling method would involve only a change in the actual procedure for selecting the sample units and in the formulas used to estimate population parameters and obtain variances of estimates. Aside from this, the sampling design recommended on the basis of this survey would remain unchanged.

SAMPLING INTENSITY

The intensity of sampling decided upon for future surveys will depend upon several factors, including the accuracy desired, the area to be covered by the survey, and the funds available. In general, the larger the area for which an estimate is to be made, the more units will be included in the sample for a given intensity and the higher will be the relative precision of the resulting estimate. Other things being equal, a larger area does not require as intensive a sample as does a smaller area to get the same relative accuracy of estimates.

In sampling an area as large as a state, separate estimates by economic areas would be desirable. This would permit comparisons of lumber consumption on farms among areas with different agricultural and lumber production and distribution characteristics. Knowing the extent of variations in lumber use within the state would be helpful in studying present lumber consumption patterns and in predicting the future demand for lumber. Estimates of lumber consumption on farms in each subdivision of a state need not be as precise or as reliable as estimates of lumber use for the state as a whole. Although it may be desirable to use 10- to 20-percent levels of significance for statewide estimates, it may be satisfactory to use only 30-percent levels of significance for estimates relating to state subdivisions.

In Minnesota Economic Area 4, a 1-percent sample resulted in a 70-percent confidence interval equal to plus or minus 22-percent of the estimate of lumber used for new construction on farms in the open country area. This estimate could have been made more precise by increasing the sampling intensity, but only at an increasing cost. To cut the 70-percent confidence interval in half, that is, to 11 percent, a sample four times larger would have to be taken. Likewise, getting the same relative precision at a higher probability level requires a more intensive sample; the sample size would have to be almost doubled to achieve 80-percent confidence limits equal to the 70-percent limits obtained in this survey.

In making statewide estimates of survey precision for various sampling intensities in Minnesota it was necessary to make several assumptions as to survey design, lumber consumption, and numbers of farms per sample unit based in part upon the experience gained in the present survey. It was assumed that: 1) estimates by economic areas were desired, 2) the sampling and estimating methods used in the present survey would be applied, 3) farms in the northeast third, southwest third, and remainder of the state respectively use 400, 600, and 500 board feet of lumber per farm each year for new construction, 4) a 1-percent sample would result in a coefficient of variation equal to 20 percent of the estimate of new construction in each economic area, and 5) economic areas in the north half of the state would have an expected number of 6 farms and in the south half 10 farms per total sample unit (two Master Sample units).

If a 70-percent confidence interval amounting to plus or minus 22 percent of the estimate were acceptable for the economic area estimates of lumber use for new construction in a statewide survey, a sampling intensity of only 1 percent would suffice. At this intensity of sampling, total and mean lumber use estimates for the entire state would have 80-percent confidence intervals amounting to about plus or minus 10 percent of the estimates. The total field cost of a survey of Minnesota with a 1-percent sampling intensity would probably be about $15,000.

If the survey budget would not permit the use of a 1-percent sample, a sampling intensity half that large would provide 80-percent confidence intervals for state estimates of new construction lumber use amounting to plus or minus 14 percent of the estimates. However, at this sampling intensity the 70-percent confidence intervals for economic area estimates are likely to be large, amounting to perhaps plus or minus a third of the estimate.

Grouping economic areas into regional economic areas would increase the precision of estimates for state subdivisions. For a given intensity of sampling, enlarging the area covered by a survey increases the sample size and hence will tend to increase the relative precision of the area estimates. This grouping would create fewer but larger regional areas which still would be relatively homogeneous with respect to climatic, physiographic, cultural, demographic, and agricultural characteristics. On future surveys, this technique probably should be used to obtain a given precision at a smaller cost.

ESTIMATING TECHNIQUES FOR LARGE-SCALE SURVEYS

Large-scale regional or national surveys, repeated at regular intervals, are needed to establish a series of data about wood consumption and use on farms. In planning for such surveys, the estimating and sampling techniques developed in this and similar pilot studies would be very helpful. The cost of a large-scale survey would vary greatly, depending upon the information and precision desired. However, one means of keeping the cost low would be to use a light sampling intensity (perhaps ½ or ¼ percent) over the entire area to get total and mean wood use, and a more intensive sampling (perhaps from 2 to 5 percent) on a few selected areas to get more detailed estimates of wood consumption and to determine relationships between wood consumption and farm characteristics. In general, estimates should be obtained on a local basis, preferably by economic areas within states, so that information about wood consumption and use could be aggregated in any manner desired.

An intensive survey such as that just described need not be made annually, but could be conducted every 5 years or so. Between intensive surveys some form of ratio estimate derived from changes on permanent sample units could be used to estimate lumber consumption each year. These annual surveys would provide estimates of known precision which would form the basis for a time series of data on farm wood consumption and use, and at a much lower cost than the more intensive surveys.

Summary

Knowledge about the present and future consumption of forest products is needed if forest managers, together with forest product manufacturers and distributors, are to make intelligent plans concerning their operations. An important but neglected part of this picture is the consumption of lumber on farms, which accounts for one-sixth of all lumber consumed in the United States. Prior studies of farm lumber consumption are inadequate or out of date.

In 1955 a cooperative study was undertaken to develop methods of estimating lumber consumption and use on farms, to obtain estimates of lumber consumption and use on farms in an area of Minnesota, and to suggest methods and costs of conducting expanded surveys of farm lumber consumption. This paper reports on the techniques for identifying and measuring lumber consumption and use on farms and the methods of sampling developed in this study, and presents recommendations for future surveys.

It was found that the best method of identifying and measuring lumber consumption and use on farms was to have field interviewers contact the farm operator and, with his help, identify and measure each piece of lumber used for various purposes on the farm during the period covered by the survey. This information was recorded so as to permit reclassification by kinds and uses of lumber in any way desired. These methods proved to be workable and efficient.

For selecting farms to be included in the survey a single random-start, systematic method of sample selection was developed. This was applied to a modified list of area sample units obtained from the Master Sample of Agriculture for Minnesota Economic Area 4. In the open country area 0.5 percent of the sample units were selected for a primary sample. In addition, a planned supplemental 0.5 percent sample was taken to augment the sample of new construction lumber use. Rural place farms were sampled in a similar manner but more intensively.

Interviewers visited each commercial and part-time farm in the primary sample and, using the special lumber estimating forms developed, identified and measured all new lumber used on the farm during 1954, classifying it by kind and use. Other pertinent information about the farm also was obtained. In the secondary sample, only farms that had used lumber for new construction were interviewed. Estimates and their variances of total and mean lumber consumption by farms in this area were obtained for different kinds and uses of lumber. The lumber estimating and farm sampling techniques developed in this study could be applied easily on a relatively large scale.

For future surveys several changes in information collected and in the sampling design used in this survey are suggested. For large-scale surveys a double sampling scheme is proposed, using a very light sample for estimating total and mean wood use for a few major kinds and uses of wood and a more intensive sample of a few selected areas for making detailed estimates of wood use and establishing relationships between wood consumption and farm characteristics. Periodic intensive surveys, with intermediate annual estimates obtained by ratio techniques, would establish a much needed series of data on wood consumption and use on farms.

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